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Understanding the Hydrogeochemical Evolution of Groundwater in Coastal Aquifers of Southwest Bangladesh

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Groundwater development in coastal aquifers of southwest Bangladesh is challenged by both natural and anthropogenic activities resulting in a landward migration of marine waters and increase in the risk of seawater intrusion. In some cases, infiltration of dissolved evaporite salts in the shallow aquifer and presence of connate water in the deep aquifer (DA) are the sources of groundwater salinity other than modern seawater intrusion. A detail investigation of these sources is imperative for a sustainable development and management of coastal aquifers. This work investigates the hydrogeochemical processes affecting groundwater chemistry by interpreting conventional plots, ionic delta, HFE-diagram, stable isotopes, and geochemical modelling. There are three hydrogeological units delineated in this area: upper shallow aquifer (USA) (<100 m bgl), lower shallow aquifer (LSA) (100-200 m bgl) and DA (below 200 m bgl). The hydrochemistry data reveal that the median values of total dissolved solids of the aquifers have a decreasing trend from top to bottom: USA with 7012 mg/l, LSA with 2622 mg/l and DA with 787 mg/l. Sodium is the dominant cation in all waters. The dominant anion in DA is HCO_3^-, but in shallow aquifers Cl^-. The main water type based on the classification of Stuyfzand (1989) is the brackish to saline NaCl type in the shallow aquifers. The Br^-/Cl^- ratio and relatively enriched $\delta^{18}O$ values in these NaCl waters suggest an origin derived from evaporate dissolution. Reverse cation exchange during intrusion, replacing Na^+ with Ca^{2+}, results in CaCl and CaMix water types. These waters infiltrate into the LSA. The water in the DA is mainly fresh $NaHCO_3$+ type which originated by cation exchange from infiltrating fresh water. Ca^{2+} was replaced by Na^+ due to the cation exchange, the water became undersaturated with respect to calcite and secondary calcite dissolution caused elevated bicarbonate concentrations. Near the present-day shoreline and at larger depths, the $NaHCO_3$+ type water mixes with connate water, increasing salinity. The enriched $\delta^{18}O$ values in the DA suggest an origin in a warmer climate, implying that this water has infiltrated a long time ago, much farther inland, probably during the Holocene climatic optimum. It can be expected that the salinization of the shallow aquifers will continue to increase if evaporite deposition and seasonal flooding occur. For a sustainable use of the groundwater resource in this coastal region and to prevent from even further worsening of water quality in its shallow aquifers, it is advised to develop future exploitations in the DA.

Key words: Groundwater chemistry; Stable isotope; Evaporite; Cation exchange; Calcite dissolution.